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CHILLED CAST-IRON ROLL.

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The present invention relates to chilled cast iron rolling mill rolls, and more especially to a roll of this character containing relatively high chromium and low phosphorus and low sulphur. We have found that by the use of relatively high chromium within the limits hereinafter specified and low phosphorus and low sulphur, together with suitable control of the carbon and silicon, a chilled cast iron rolling mill roll may be produced having both extraordinary hardness and extraordinary strength and toughness.

The roll is a cast iron roll, as distinguished from a steel roll or a so called "Adamite" roll. The melt should be made up in a furnace in which the control of the low phosphorus and sulphur can be attained, such, for example, as an air furnace, an open-hearth furnace or an electric furnace. The charge may be made up in the usual way of pig iron, scrap and ferrochromium additions. The metal is cast in chill molds of the usual character. Such molds may consist of a heavy chill around the entire body of the roll or may consist of bands which chill certain portions of the body. The chilling bands may be heavy or light, as is the practice in making the heavily chilled rolls or the lighter chilled rolls, sometimes called condensed grain rolls.

The carbon of the roll is within the ranges of carbon for cast iron rolls. The carbon may vary from about 2.25% to about 3.75% or even as much as from about 2% to 4%. The chromium is much higher than has been usually employed in making chilled cast iron rolls. The chromium may vary from about 2% to 3%, or even from 1.80% to 4%, although we prefer to have the chromium somewhere about 2.25% to 2.75%. The phosphorus is kept low. The phosphorus should not exceed about .30%, preferably not over about .2% or .15%, and for best results not over .10%. The sulphur should also be kept low, not over about .20%, preferably not over about .15% or .10%, and for the best results not over about .08%. The manganese may vary within the usual ranges, say from about .10% to 1.50%, preferably from about .15% to about .75% or 1%. The silicon will be varied in accordance with the carbon and chromium and the size of the roll. The silicon will ordinarily be within the ranges from about .50% to 2.25% or 2.50%, preferably over 1%. The silicon will ordinarily be higher than that of the usual chilled iron rolls. The control of the silicon, together with the chromium and carbon, is important in giving the extraordinary toughness to the roll. It is preferred to use enough silicon so that there will be a very slight precipitation of graphite through the chill portion of the roll. By this, we do not mean that the chill portion of the roll will be of a gray or mottled iron. The chill portion of the roll is predominately a white iron, but is characterized by microscopic flecks of graphitic carbon throughout its greater part. Under some conditions, there may be a relatively thin zone or skin of pure white metal at the free surface of the roll, but the greater part of the chill portion of the roll preferably exhibits the fine, graphitic carbon.

The tendency of the high carbon is, of course, to precipitate as graphite. This tendency is, however, restrained by the relatively high chromium content. The chromium tends to hold the carbon in the combined form, and when chilled, to produce a white iron which, although it tends to be hard, is inclined to be brittle. We have found that if the action of the carbon and chromium is suitably controlled by the silicon to a point where a very small but appreciable amount of graphitic carbon is precipitated, the roll will be much stronger than an ordinary chilled iron roll and will also have a greater hardness due to its high chromium and carbon. The amount of silicon and carbon employed also tends to counteract the tendency of the chromium to make the hot metal mushy and assists in the control and pouring of a heat of the metal.

There is a greater tendency toward white iron in the interior of the roll than with the usual chilled iron roll, due to the high chromium. This is apparently the cause of the gradual and imperceptible shading off of the metal structure from the exterior toward the interior of the roll. At the surface of the roll where the metal is more heavily chilled, the metal will be predominantly a white iron which preferably contains a small but still microscopically distinguishable amount of finely distributed graphitic carbon. In going from the surface of the roll toward the interior, there is no abrupt change in the grain structure of the metal or in the amount of graphitic carbon, as is the case in the

ordinary chilled roll, where there is a fairly distinct line of demarkation between the chilled portion and the underlying core of mottled iron.

The graphite in the chilled portion exists in a very finely divided form. The granules though distinguishable by a microscope, are so fine as not to be readily distinguishable by the eye. Because of the fineness of the graphitic carbon, the iron looks more like a white iron than it does like a gray iron. In going toward the interior of the roll, the size of the graphitic particles as well as the total amount of precipitated carbon gradually but imperceptibly increases until at the interior of the roll, the metal is of a mottled iron structure which has a greater tendency toward white iron than that of the core of the usual chilled iron roll. The roll, therefore, appears to have a relatively deep chill which gradually tapers off or disappears toward the interior of the roll. This adapts the roll particularly for work in which grooves are to be cut into the roll. Also it permits the rolls to be turned down considerably before their usefulness is destroyed.

While ordinarily the presence of a small but appreciable amount of finely divided graphitic carbon will persist to the very exterior of the roll, under some circumstances, the exterior or skin of the roll may be of a practically pure white iron, particularly in the case of heavy chilling and toward the lower ranges of the silicon and carbon and upper ranges of the chromium. When such white iron skin or zone occurs, it merges gradually and imperceptibly into the underlying metal in which the finely divided graphitic carbon is present.

The chill portion of our roll is characterized, as contrasted with the ordinary chill, by the presence of the small but appreciable amounts of very finely divided graphitic carbon and by its gradual and imperceptible merger with the metal at the interior of the roll. The chill, while containing a small amount of graphitic carbon, is nevertheless hard as, and usually harder than, the ordinary white iron chills. We believe that the extraordinary hardness of the chill is due to the combination of the chromium with the carbon and that the extraordinary strength in the presence of the high chromium is due to the condition of the iron brought about by the control of the chromium, carbon and silicon, in which the small amount of microscopically distributed graphitic carbon is present.

The chromium is one of the cheapest alloying metals and we are enabled to get the combined strength and hardness by the use of chromium alone, and without the more expensive alloying metals which have been suggested for use in chilled cast iron rolls. However, small amounts of other alloying elements may be present, if desired, such for example, as small amounts of nickel, cobalt, uranium, vanadium, molybdenum, tungsten, etc.

While we have described the preferred embodiment of our invention, both as to its preferred analyses and preferred physical characteristics, it is to be understood that the invention is not so limited, but may be otherwise embodied within the scope of the following claims.

We claim:

1. A chilled cast iron roll containing carbon about 2% to 4%, chromium about 1.80% to 4%, phosphorus not over about .30%, sulphur not over about .20%, manganese about .10% to 1.50%, and silicon about .50% to 2.50%, the silicon, carbon and chromium being so proportioned as to produce a chill containing a small but appreciable amount of very finely divided graphitic carbon and the said chill merging gradually and without abrupt change of grain structure into a core of mottled iron which has a greater tendency toward white iron than that of the usual chilled iron roll.

2. A chilled cast iron roll containing carbon about 2% to 4%, chromium about 2% to 4%, phosphorus not over about .30%, sulphur not over about .10%, manganese about .10% to 1.50%, and silicon about 1% to 2.50%, the silicon, carbon and chromium being so proportioned as to produce a chill containing a small but appreciable amount of very finely divided graphitic carbon and the said chill merging gradually and without abrupt change of grain structure into a core of mottled iron which has a greater tendency toward white iron than that of the usual chilled iron roll.

In testimony whereof we have hereunto set our hands.

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